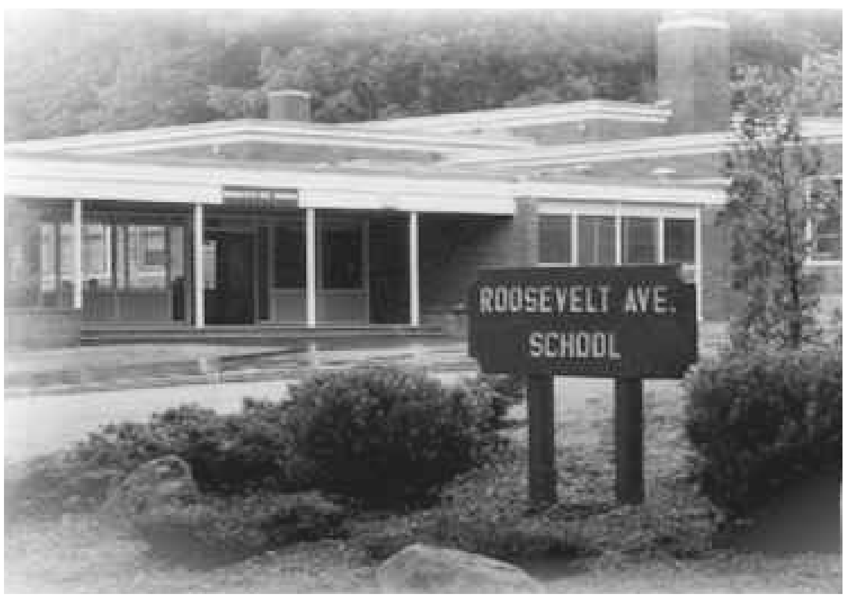
INDOOR AIR QUALITY ASSESSMENT

Roosevelt Avenue School
108 Roosevelt Avenue
North Attleborough, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
December 2004

Background/Introduction

At the request of the North Attleborough School Department, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH) Bureau of Environmental Health provided assistance and consultation regarding indoor air quality at the Roosevelt Avenue School (RAS), 108 Roosevelt Avenue, North Attleborough, Massachusetts. On October 6, 2004, Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an indoor air quality assessment. Don Tibbetts, Head Custodian accompanied Mr. Holmes during the assessment.

The RAS is a single-story red brick building that was constructed in 1955. A single-story addition was built in the mid-1970s. Two portable classrooms were added in 1993 and serve as the school's library and computer lab. The building has a history of roof leaks and water damage. A new roof was installed and drainage was improved over the summer of 2004. A number of areas have new ceiling tile systems. Windows are openable throughout the building.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were taken with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). BEHA staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 241 kindergarten through fifth grade students and approximately 30 staff members. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) parts of air in four of twenty areas surveyed, indicating adequate air exchange in the majority of areas surveyed. Fresh air in classrooms is supplied by a unit ventilator (univent) system (Pictures 1 and 2). Univents are designed to draw air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 3) and return air through an air intake located at the base or sides of each unit (Figure 1/Picture 1). Fresh and return air are mixed and filtered, then heated and provided to classrooms through an air diffuser located in the top of the unit. Univents have manual fan controls of low, medium and high to adjust fan speed (Picture 4). Obstructions to airflow, such as papers and books stored on univents and bookcases, carts and desks in front of univent returns, were seen in a few classrooms. In order for univents to provide fresh air as designed, units must remain free of obstructions.

Exhaust ventilation in classrooms is provided by ducted, grated wall vents powered by rooftop motors (Pictures 5 to 7). A number of exhaust vents were not operating, indicating that motors were deactivated or non-functional. BEHA staff and Mr. Tibbetts examined exhaust motors on the roof and found several not operating. A number of exhaust vents were also obstructed by desks, bookcases and other items (Picture 5). As with the univents, in order to function properly, exhaust vents must be activated and remain free of obstructions. In addition, the location of some exhaust vents can limit exhaust efficiency. In the 1970s wing, exhaust vents are located above hallway doors (Picture 6). When classroom doors are open, exhaust vents will tend to draw air from both the hallway and the classroom reducing the effectiveness of the exhaust vent to remove common environmental pollutants.

The cafeteria is designed to be ventilated by air handling units (AHUs). The AHUs are located above the stage area and provide supply air through vents near the ceiling. Air is ducted back to the AHUs via return vents on the front of the stage (Picture 8). The system was not operating during full occupancy at lunch period during the assessment.

Ventilation for modular classrooms is provided by rooftop AHUs (Picture 9). Fresh air is distributed to classrooms via ductwork connected to ceiling-mounted air diffusers and drawn back to the units through ceiling-mounted grilles (Picture 10). Thermostats that control each heating, ventilating and air conditioning (HVAC) system have fan settings of “on” and “automatic”. Thermostats were set to the “automatic” setting (Picture 11) in both of the modular rooms during the assessment. The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools because a majority of occupants is young and considered a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix A.

Temperature readings ranged from 65^{o} F to 78^{o} F, which were below or near the lower end of the BEHA recommended comfort guidelines in a number of areas during the assessment.

The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., AHUs not operating, exhaust vents obstructed/deactivated).

The relative humidity measurements ranged from 29 to 46 percent, which were below the BEHA recommended comfort range in several areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity would be expected to drop below comfort levels during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The building has a history of roof leaks and water damage. A new roof and ceiling tile systems in many classrooms were installed during the summer of 2004. Concerns of mold growth on fiberglass insulation above ceiling tiles were expressed in classroom 14. BEHA staff and Mr. Tibbetts removed a number of tiles to examine conditions in the ceiling plenum. The area appeared dry and no visible mold growth and/or associated odors were observed/detected.

Spaces between the sink countertop and backsplash were noted in several classrooms (Table 1/Picture 12). Improper drainage or sink overflow can lead to water penetration of countertop wood, the cabinet interior and areas behind cabinets. A leaking faucet was observed beneath the cabinet in classroom 11. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

Fiberglass insulation was observed to be used around window-mounted air conditioners to block drafts. In several areas, the insulation was exposed to moisture on the exterior of the building (Picture 13). The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND. Although no carbon monoxide was detected in the school, BEHA staff noted a slight natural gas odor upon entering the cafeteria. The source of the odor was a gas stove in the kitchen (Picture 14). The vent hood above the stove is not motorized and was found backdrafting during the assessment. Backdrafting can pressurize the kitchen and distribute gas odors and combustion products into adjacent areas.

The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average. This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average. Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 10 $\mu g/m^3$. PM2.5 levels measured indoors ranged from 6 to 22 $\mu g/m^3$ (Table 1). Although PM2.5 measurements were above background in some areas, they were below the NAAQS level of 65 $\mu g/m^3$. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC measurements throughout the building were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While no measurable TVOC levels were detected in the indoor environment, VOC-containing materials were noted. Cleaning products were found on countertops and beneath sinks in a number of classrooms (Picture 15). Cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students.

Several areas contain photocopiers and lamination machines. Lamination machines can produce irritating odors during use. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992). These areas are not equipped with local exhaust ventilation to help reduce excess heat and odors.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 16). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and cause TVOCs to off-gas. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Finally, the amount of materials stored inside some classrooms is also of note. Items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to prevent excessive dust build up.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers.

2. Operate all ventilation systems that are operable throughout the building (e.g., cafeteria, classrooms) continuously during periods of school occupancy and independent of thermostat control. To increase airflow in classrooms, set univent controls to “high”.
3. Set the thermostat for modular classrooms to the fan “on” position to operate the ventilation system continuously during the school day.
4. Inspect exhaust motors and belts for proper function. Repair and replace as necessary.
5. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
6. Consider having ventilation systems re-balanced every five years by an HVAC engineering firm.
7. Consider installing mechanical exhaust ventilation in the kitchen and copy room to remove excess heat, combustion products and pollutants.
8. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
9. Ensure roof leaks are repaired and repair/replace any remaining water-stained ceiling tiles and/or plaster. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
10. Move plants away from univents in classrooms. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.

11. Change filters for air-handling equipment (i.e., univents, AHUs, window mounted ACs) as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.
12. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
13. Store cleaning products properly and out of reach of students.
14. Consider discontinuing the use of tennis balls on chairs to prevent latex dust generation.
15. Consider developing a written notification system for building occupants to report indoor air quality issues/problems. Have these concerns relayed to the maintenance department/ building management in a manner to allow for a timely remediation of the problem.
16. Consider adopting the US EPA (2000b) document, "Tools for Schools", to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.
17. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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Picture 1

1950's Vintage Univent, Note Return Vents on Sides of Univent

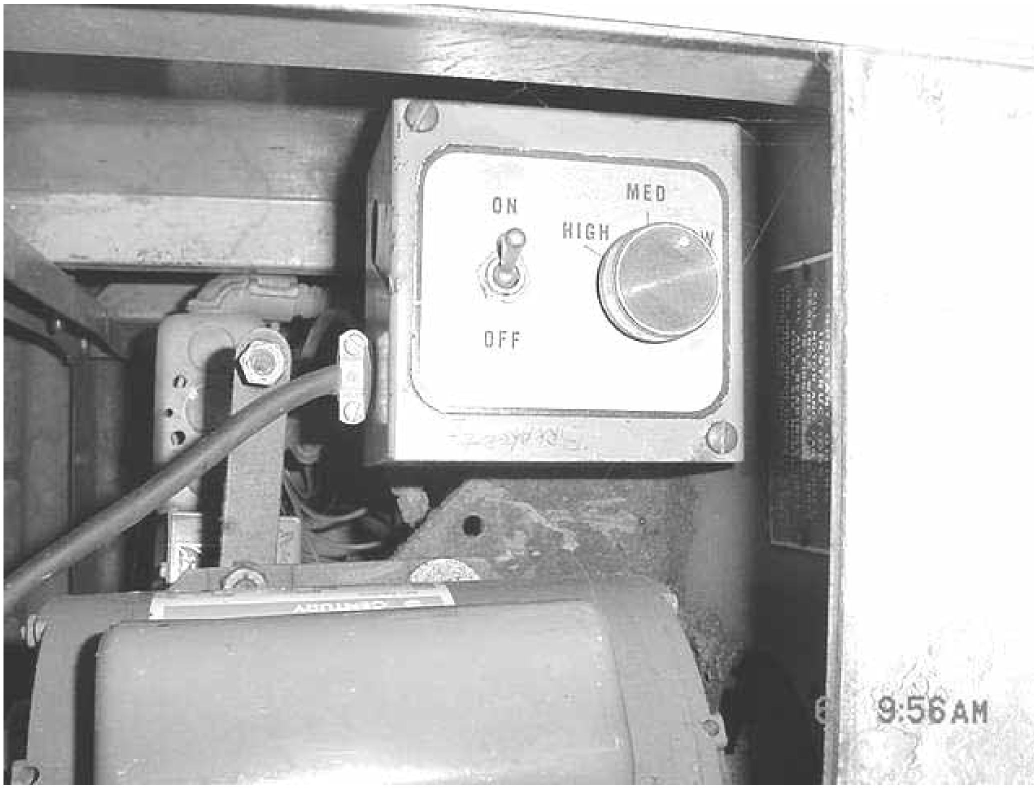
Picture 2

Modern Univent in 1970's Addition

Picture 3

Univent Air Intake

Picture 4



Interior Univent Control Panel

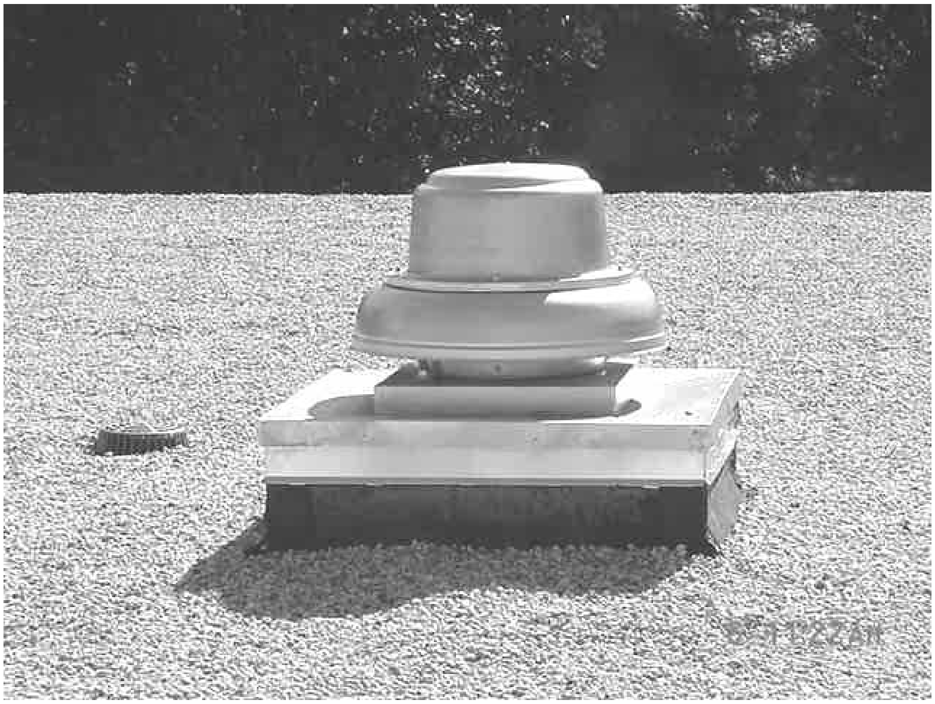
Picture 5

Obstructed Exhaust Vent, Note Proximity to Open Hallway Door

Picture 6

Exhaust Vent in 1970's Addition, Note Open Hallway Door

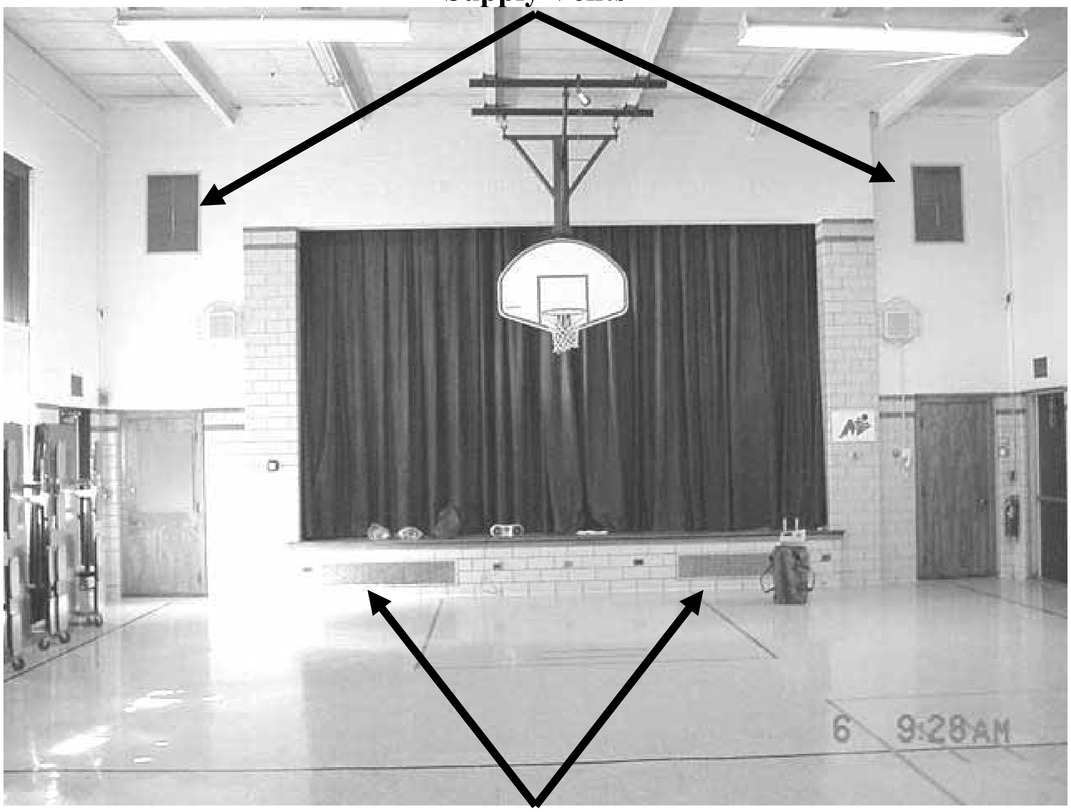
Picture 7



Rooftop Exhaust Motor

Picture 8

Supply Vents



Exhaust /Return Vents

Mechanical Supply and Exhaust System in All-Purpose Room

Picture 9

Modular Classroom Rooftop AHU

Picture 10

Supply and return Vents in Ceiling of Modular Classroom

Picture 11

Thermostat for Modular Classroom AHU, Fan Switch Set to "Auto" (Bottom Left)

Picture 12

Breach between Sink Countertop and Backsplash

Picture 13

Exposed Fiberglass Insulation around Window-Mounted Air Conditioner

Picture 14

Non-Motorized Vent Hood above Gas Stove in Kitchen

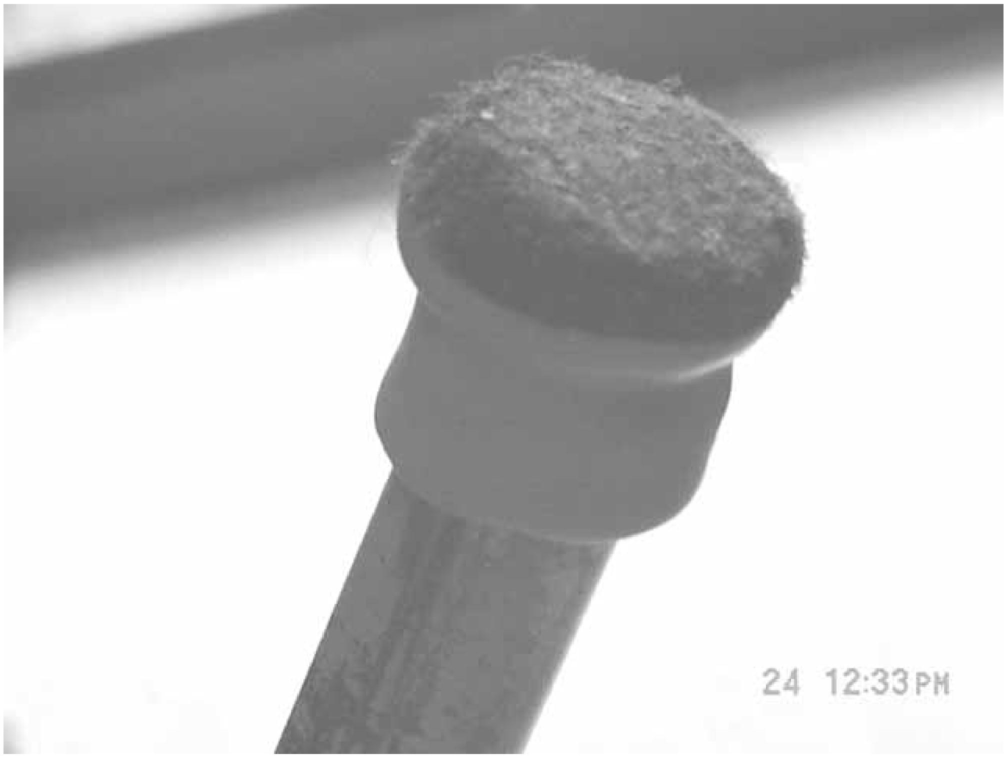
Picture 15

Cleaning "Spray" Products under Sink Cabinet in Classroom

Picture 16

Tennis Balls on Chair Legs in Classroom

Picture 17



“Glides” for Chair Legs that can be used as an Alternative to Tennis Balls

Roosevelt Avenue School **Indoor Air Results**

Roosevelt Avenue, North Attleborough, MA **Table 1** **October 6, 2004**

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background (outdoors)	57	46	363	57	ND	10		-	-	-	Atmospheric Conditions: cool, clear
Cafeteria/ Gymnasium	65	43	444	ND	ND	7	0	Y	Y	Y	DO, AHUs deactivated, slight gas odors from kitchen equipment
Kitchen	66	44	468	ND	ND	7	0	Y	N	Y	Vent hood over gas stove not motorized, slight gas odors, vent backdrafting
Computer Lab (portable classroom)	70	43	320	ND	ND	8	0	Y	Y	Y	DO, DEM
Library (portable classroom)	68	41	352	ND	ND	6	0	Y	Y	Y	Thermostat fan – Auto, dusty return vents, lamination machine
1	72	42	869	ND	ND	11	21	Y	Y	Y	Stuffed animals, UV obstructed by furniture and clutter, DEM

ppm = parts per million parts of air
CT = ceiling tile
AD = air deodorizer
AP = air purifier
CD = chalk dust

µg/m3 = microgram per cubic meter
WD = water damage
DEM = dry erase marker
DO = door open
PC = photocopier

UV = univent
CF = ceiling fan
PF = personal fan
TB = tennis balls
UF = upholstered furniture

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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									Supply	Exhaust	
2	72	40	911	ND	ND	12	20	Y	Y	Y	UV – on low setting and obstructed by clutter and furniture, DEM,
3	72	41	789	ND	ND	16	22	Y	Y	Y	PF-dusty, DEM, 1 window open
4	71	41	731	ND	ND	12	21	Y	Y	Y	DEM, DO
5	71	41	795	ND	ND	17	20	Y	Y	Y	DEM, exhaust vent obstructed by clutter
6	70	46	795	ND	ND	14	19	Y	Y	Y	DEM, PF
K	74	40	756	ND	ND	12	17	Y	Y	Y	Gravity exhaust vent (fireplace), window ACs (2), plants
Nurses' Office	70	39	711	ND	ND	13	1	Y	N	Y	Window AC, DO

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7	74	32	889	ND	ND	22	24	Y	Y	Y	Exhaust-off, PF, TB, DEM
8	75	33	746	ND	ND	9	25	Y	Y	Y	Exhaust – off, DEM, breach sink/countertop, PF, DO, TB
9	75	32	748	ND	ND	9	17	Y	Y	Y	Exhaust – off, DEM, stick-up air freshener, cleaning products, DO
10	75	32	694	ND	ND	8	22	Y	Y	Y	Exhaust – off, DEM, UV return vent obstructed by clutter/furniture, cleaning products, breach sink/countertop, PF
11	75	29	480	ND	ND	6	6	Y	Y	Y	Exhaust – off, DEM, leak under sink in cabinet, PF, TB, breach sink/countertop
12	77	35	568	ND	ND	15	0	Y	Y	Y	Exhaust – off, DEM
Copy Room								N	N	N	PC and lamination machine

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14	78	30	503	ND	ND	14	4	Y	Y	Y	Exhaust – off, DEM, cleaning products/unlabeled spray bottle under sink, concerns of mold/water damaged insulation above ceiling tiles
Cafeteria	68	46	936	ND	ND	14	~120	Y	Y	Y	AHUs not operating, 4 windows open

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